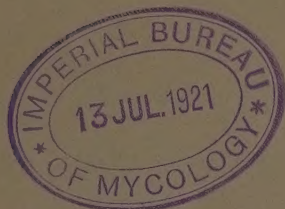


FLORA W. PATTERSON,

CROWN GALL AND HAIRY ROOT.

Mel. T. Cooke.

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NEW JERSEY

AGRICULTURAL

Experiment Stations

CIRCULAR 34

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AGRICULTURAL EXPERIMENT STATIONS
CIRCULAR 34

Crown Gall and Hairy Root.*

The diseases discussed in this bulletin are of very great interest to both nurseryman and fruit grower. The fact that they are so very widely distributed throughout the world and that they attack such a very large number of species and varieties of plants, places them among the most important of the plant diseases. Although we shall refer to them as two diseases, they are in reality due to the same organism. The crown gall form was the first to attract the attention of the observers but it was soon learned that hairy root was frequently associated with it.

The question of the relatively injurious effects of these diseases has given rise to a very great diversity of opinion among horticulturists, nurserymen and plant pathologists. Owing to this diversity of opinion, the writer considers it advisable to present this circular giving the history of these diseases and the latest information obtainable concerning them. The statements contained herein are taken largely from the writings of other workers, but the author has also inserted his own observations. The workers whose results are most frequently referred to are Dr. George G. Hedgcock, Dr. Erwin F. Smith and other workers of the United States Department of Agriculture.

* Prepared by Mel. T. Cook, Ph.D., Plant Pathologist, New Jersey Experiment Station.

History.

The diseases have been known for 50 or possibly 75 years, and have been attributed to many causes. They have been reported from practically every State in the Union, from Canada, South America,



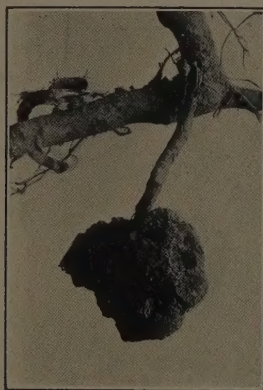
CROWN GALL ON RED RASPBERRY. NATURAL SIZE

South Africa, Europe and Asia. Crown gall was reported by Thaxter from Connecticut in 1891, from New Jersey by Halsted in 1897, from New York by Bailey in 1897, from Ohio by Selby in 1898, and was the subject of a bulletin by Toumey of Arizona in 1900. Dr.

Hedgcock's publications began about 1905, and Dr. E. F. Smith's about 1907.

In April, 1907, Smith and Townsend gave the first satisfactory proof as to the cause of these diseases. Their work began in February, 1904, upon diseased Paris daisy plants (*Chrysanthemum frutescens*) which were sent to the United States Department of Agriculture from New Jersey. After long and continued study they determined the diseases to be due to a bacterial organism which they named *Bacterium tumefaciens*. Repeated experiments by these writers and others all tend to demonstrate the correctness of their discovery.

The disease in one or both forms is now recognized as occurring

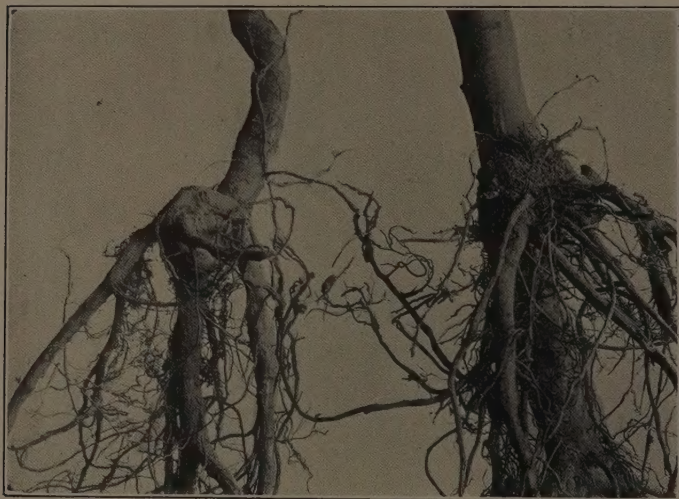


CROWN GALL ON CHERRY

on almond, apple, apricot, arbutus, alfalfa, blackberry, beet, cherry, chestnut, clover, corn, cotton, dewberry, Euonymus, English daisy, grape, hop, honeysuckle, marguerite or Paris daisy, marigold, oxeye daisy, oleander, peach, plum, prune, pear, pyrethrum, potato, poplar, pecan, peony, raspberry, rose, radish, Shasta daisy, walnut, willow, and many other plants. On many of these plants it would be of very little importance were it not that they serve to carry the organism from season to season and from place to place. On many plants it is quite serious, reducing their vitality and fruitfulness. In commerce its greatest importance in this State is on apples, pears,

peaches, plums, cherries, grapes, raspberries, blackberries, and dewberries.

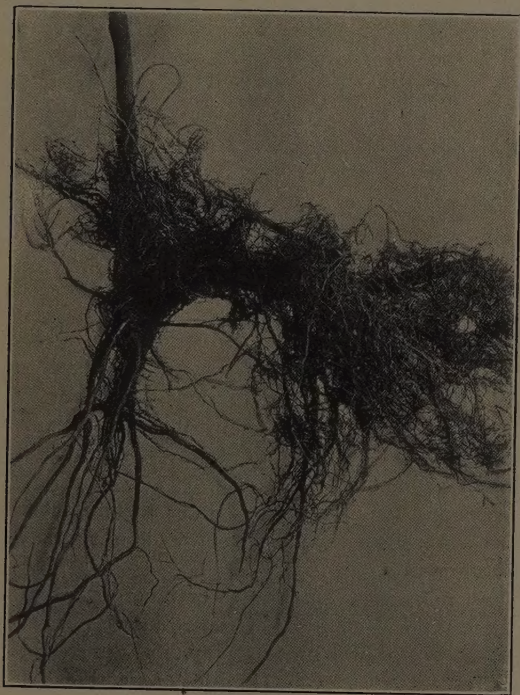
As previously stated, the disease is due to a bacterial organism, living in the cells of the host plant and stimulating them to excessive activity, which results in the formation of cancerous and hairy growths occurring at the crown, on the roots, trunks and branches of the affected plants. The disease takes somewhat different forms on different host plants. On herbaceous plants and cane fruits it usually causes the *soft galls* which originate in the spring, and are



NURSERY APPLE STOCK
CALLOUS ON THE LEFT. CROWN GALL AT POINT OF UNION
ON THE RIGHT

irregular in size, more or less spherical in shape, whitish and slightly roughened. They usually occur at the crown or on the roots, but frequently occur on the stems, 12 or 18 inches above the ground. During the latter part of the season they usually decay and slough off. The plant may survive the attack, but some of the roots will be killed and undergo a decay, permitting the entrance of other organisms of disease. On hard, woody plants, the disease may take the

form of a *hard gall*, which does not decay so readily but continues to grow and increase in size from year to year. The injurious effects of this form will vary greatly with the species or variety of the tree and with the location of the gall. On apple and some other plants it may take the *hairy root* form, in which it produces a flat gall or callos covered with a great mass of hair-like roots arising at right



HAIRY ROOT ON APPLE

angles to the surface. However, it should be remembered that *hairy root* may also be due to other causes. The disease may also appear on the trunk and branches, either as galls or as flat roughened areas covered with papillæ and known as the *aerial* form.

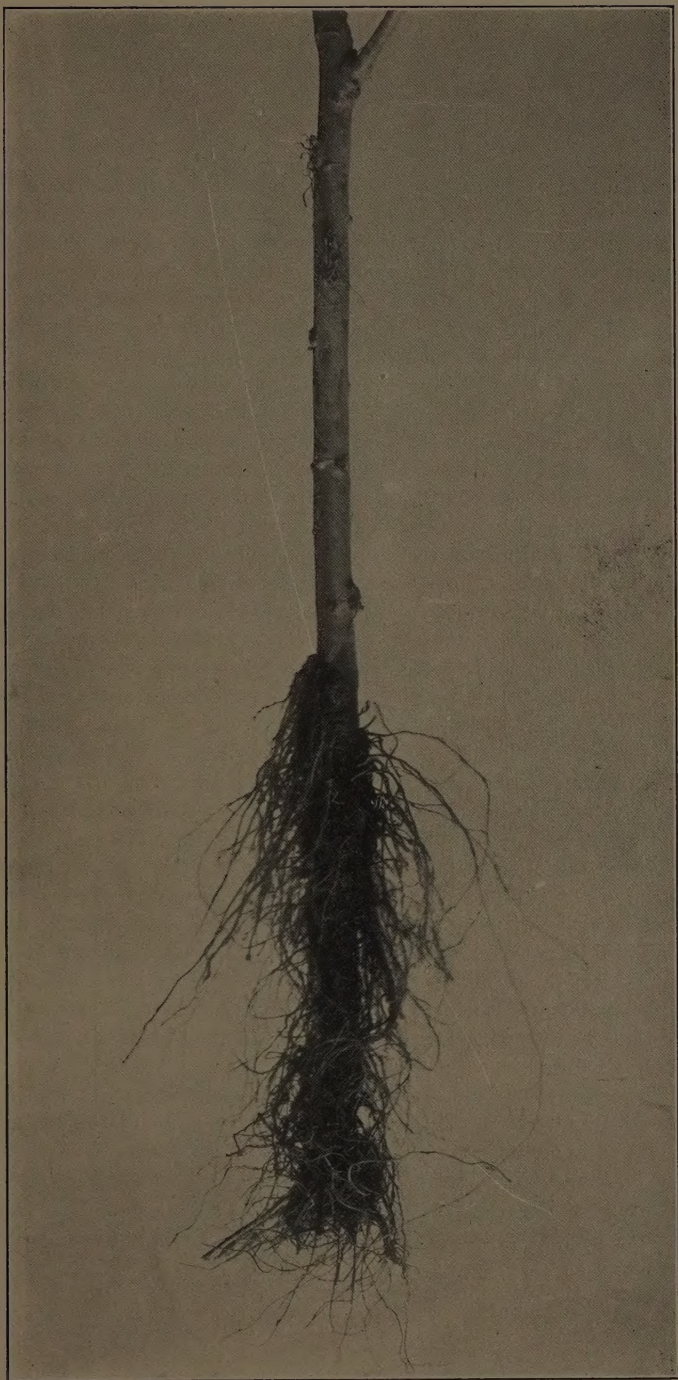
Sometimes the disease appears to be restricted to certain parts of

the plant while in other cases it appears at numerous places on the plant. Experimental work by Dr. E. F. Smith and others show that the disease having gained entrance to the plant works its way through the tissues, giving rise to the abnormal growths at various points which may be at a considerable distance from the original point of infection. This makes it impossible to cut out the galls with any certainty of removing the disease and no doubt accounts for the many contradictory statements concerning the efficiency of this treatment. If the gall is located at the crown it is extremely doubtful whether its removal will ever free the tree from the disease. When located on the lateral roots the curative value of its removal will depend on the extent to which it may have penetrated to other parts of the plant, a point which cannot be readily determined. Therefore, the practice of some nurserymen and growers of pruning out these galls is to be condemned.

The organism persists in the soil for an unknown period of time, gaining entrance to the healthy host plant through wounds made by cultivation, pruning, budding, grafting, insects, etc. It has been quite generally noted that root-grafted stock is much more likely to contract the disease than budded stock, and especially root-grafted trees wrapped with waxed string or raffia instead of waxed cloth. Scions from diseased trees, especially those that show the *aerial* form, when budded or grafted into healthy stock, will carry the disease as readily as the diseased roots.

Galls, knots and hairy root may be due to other causes, but the experienced worker can usually recognize the diseases due to *Bacterium tumefaciens*.

Among the most important causes of other forms of knots and hairy root are the following: (1) Galls caused by using stock and scion which do not grow with equal rapidity. (2) Improper wrapping of grafts and buds. (3) The breaking of the roots in transplanting nursery stock. (4) The heavy application of nitrogenous fertilizer, causing hairy root. (5) Insects such as *Schizoneura lanigera* or woolly aphis on the apple, the *Phylloxera vastatrix* on the grape, and *Rhodites radicum* and related insects on rose and blackberry. (6) *Nematodes* (microscopic worms) which attack a very large number of plants and are especially severe in warm climates. (7) Slime moulds such as *Plasmidiophora brassicae* which causes



APPLE FROM GERMANY. NOTE THE HAIRY ROOT AND
ALSO THE AERIAL FORM ON THE TRUNK

the club root of cabbage and related plants. (8) Other bacterial organism such as *Bacterium savastanoi*, causing the olive knot, and *Pseudomonas radicicola*, causing the nodules on clover and other leguminous plants. (These nodules on legumes are beneficial.)

That crown gall and hairy root are serious diseases cannot be doubted. That they may be much more serious in some localities than others and upon some plants than on others is equally true. Of the fruits of this State it may be said that they are most injurious on cane fruits, especially red raspberries; that they frequently prove very injurious to peach trees and sometimes to apple trees. Heavy applications of fertilizer tend to reduce the injurious effects on many varieties, but it would be more profitable for the grower to feed healthy plants than diseased plants.

The great difference of opinion concerning these diseases expressed by various workers in the past can be readily explained by our increasing knowledge of the subject. It is very generally conceded that the distribution of these diseases is largely due to nursery stock: that cane fruits, especially red raspberries, are notorious carriers of these diseases, and that certain varieties of apple, such as Wealthy, Yellow Transparent, Wolf River, Ben Davis and Northern Spy, are especially susceptible. Certain varieties of grapes and berries are also more susceptible than others. The disease is not necessarily fatal, but diseased trees are frequently more or less stunted and sometimes die from the effects of this disease. The root system of many varieties will be imperfect and the trees can be readily blown out by storms and cannot produce the maximum crop of fruit. Certain varieties when affected will produce a much smaller crop than healthy trees. Such trees will occasionally produce good crops, but do not thrive and produce as well as healthy trees under the same treatment. When the disease is predominant at the crown the possibility of growing fruitful trees, even of the hardiest varieties, is greatly reduced.

The effects of these diseases on ornamental plants has received very little attention. During the summer of 1913 the writer was called on to examine certain plantings on a large estate in New Jersey. Among other things, attention was called to a fine group of Bolleana poplars which were dying. An examination of these trees showed an abundance of galls on roots, trunks and branches which



HAIRY ROOT ON SEEDLING APPLE

were evidently causing the trouble. Careful inquiry into the history of the planting convinced the writer that the trees were diseased from the nursery.

These diseases are so widely distributed that their eradication is practically impossible, but they can be very greatly reduced. The buyer of a tree is entitled to a healthy tree and no fruit grower can afford to set inferior or diseased plants. The inspection laws in the different states are becoming more and more strict with stock likely to carry these diseases, every year. By observing the following rules these diseases can be reduced to a minimum:

Nurserymen should

1. Grow their stock on ground as nearly free from these diseases as possible. Never use ground which has recently been set with cane fruits.

2. Avoid injuring the young trees by cultivation.

3. Use the best grade, healthy seedlings for budding and grafting.

4. Use scions and buds from trees known to be absolutely healthy. The roots, trunk and branches of trees from which the scions are cut should be free from all forms of the disease.

5. When root-gall is prevalent, budding is much to be preferred to root grafting, especially with susceptible varieties such as Wealthy.

6. If root grafting is practiced the following precautions should be taken :

Make close fitting grafts, leaving no exposed cut surfaces.

Wrap each graft well with soft waxed cloth.

Avoid wrapping with waxed string or raffia.

Store root grafts in clean moist sand at temperatures above 32 degrees but not to exceed 35 to 40 degrees.

Plant as early in spring as soil conditions permit.

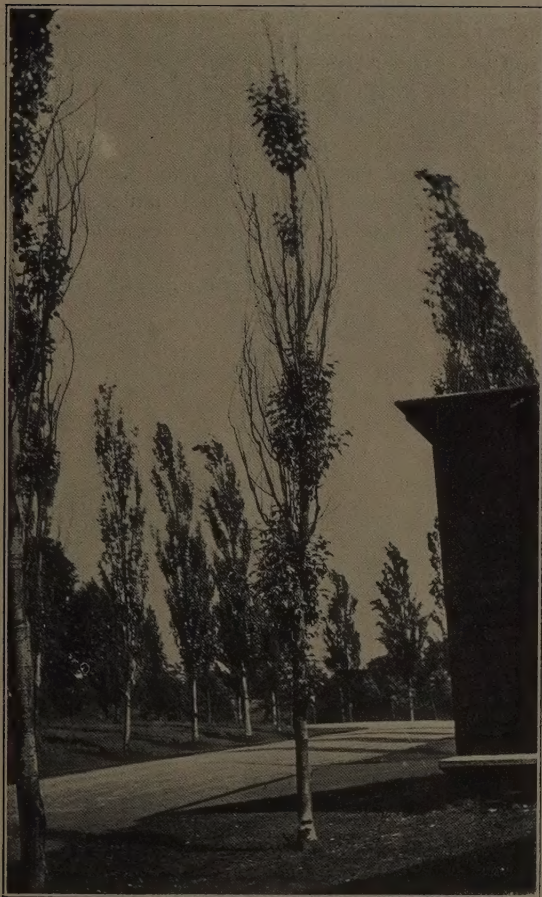
Handle grafts carefully in planting so as not to make any wounds upon the roots or disturb the callous formation upon the cut surfaces of scion and stock.

Avoid injury to plants in subsequent cultivation.

7. "Propagate by budding, so far as possible, the few varieties most susceptible to crown gall and hairy root."—Hedgecock.

8. "Avoid heavy, wet soils."—Hedgecock.

9. Burn all diseased plants. Do not prune the evidently diseased



BOLLEANA POPLAR DYING FROM CROWN GALL

parts and market the stock. The disease may have penetrated farther than you can determine.

The fruit grower should

1. Refuse all diseased stock. His time, land and fertilizer are too valuable for him to gamble with diseased plants of any kind.
2. Set the plants on land as free as possible from the disease. Avoid land that has been used for cane fruits.
3. Never use cane fruits as inter-row crops.
4. Avoid injuring the trees by cultivation so far as is possible.
5. Keep trees as free from borers and similar pests as possible and paint the wounds made in removing borers with white lead paint or coal tar.
6. Rotate old orchard and berry lands to grains, potatoes or similar crops if possible.



BOLLEANA POPLAR SHOWING AERIAL FORM OF CROWN GALL

